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Smt. Indira Gandhi College of Engineering
NAVI MUMBAI
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Report On Industrial Visit of Power Electronics HVDC Station, Padaghe
B.E/Electrical

Subject: - **Power Electronics Design Lab**
Subject Code: - EEL 703

Subject In charge
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Objective of Industrial visit

- Understanding the working of power electronic converters in HVDC systems.
- Familiarizing with advanced power electronics components like thyristors and IGBTs.
- Learning about HVDC system architecture and converter station design.
- Observing real-time operations and grid stability mechanisms.
- Analyzing efficiency optimization and loss reduction in HVDC transmission.
- Studying control, protection, and fault management systems.
- Exploring the environmental and economic benefits of HVDC technology.
- Learning about maintenance and troubleshooting practices.
- Gaining insights into future developments in HVDC and power electronics.

Introduction

The Maharashtra State Electricity Board (MSEB) built a 1,500 MW HVDC link between the cities of Chandrapur and Padghe (near Mumbai) – the first HVDC transmission link to Mumbai. The converter terminals were constructed by ABB (Sweden and India) and Bharat Heavy Electricals Limited (BHEL) of India. The 500 kV Chandrapur – Padghe HVDC Bipole feeds Mumbai on the west coast with 1,500 MW from a thermal power generation plant located near Chandrapur in the eastern part of Maharashtra State 752 km away. The link helps to stabilize the Maharashtra grid, increasing power flow on the existing 400 kV AC lines while minimizing total line losses.

Figure: -HVDC SUBSTATION PADGHE

Power electronic Converter technology has emerged as a pivotal solution in electrical power transmission, particularly for long-distance energy transfer and the integration of renewable energy sources. HVDC substations play a crucial role in this system by converting alternating current (AC), often generated from conventional power plants or renewables, into direct current (DC) for enhanced efficiency.

Key Features of HVDC Substations

1. Efficiency: HVDC transmission systems minimize electrical losses over long distances, making them ideal for connecting remote energy sources to urban demand centers.
2. Stability and Control: HVDC substations provide better voltage control and system stability, reducing the risk of oscillations that can affect AC transmission lines.
3. Grid Interconnections: They facilitate interconnections between asynchronous power grids, allowing for improved reliability and flexibility in energy sharing.
4. Reduced Right-of-Way Requirements: HVDC lines can transmit greater amounts of power through narrower corridors compared to traditional AC lines, reducing land use and environmental impact.
5. Integration of Renewable Energy: By enabling the smooth incorporation of wind, solar, and other renewable sources, HVDC substations are vital to the transition toward sustainable energy systems.

Figure: -Power Transformer

Components of an HVDC Substation

1. Converters (Rectifiers and Inverters)

- **Function**: The core components of HVDC systems, converters convert **AC (Alternating Current)** to **DC (Direct Current)** for transmission and vice versa.
- **Types**:
  - **Line-Commutated Converters (LCC)**: Use thyristors to convert AC to DC and DC to AC.
  - **Voltage Source Converters (VSC)**: Use insulated-gate bipolar transistors (**IGBTs**) or gate turn-off thyristors (**GTOs**) for more flexible and efficient conversion.

2. Thyristors

- **Function**: A type of semiconductor switch used in **line-commutated converter (LCC) HVDC systems** to control high power levels.
- **Working**: Thyristors allow current to flow when triggered, and they remain on until the current falls to zero (natural commutation in LCC).
- **Application**: They are used in high-power converters for AC to DC conversion in traditional HVDC systems.

3. Insulated Gate Bipolar Transistors (IGBTs)

- **Function**: IGBTs are used in **Voltage Source Converter (VSC) HVDC systems** for switching and controlling the flow of power.
- **Working**: These semiconductors allow for fast switching, which enables finer control over power flow and conversion, improving system flexibility.
- **Application**: VSC-HVDC systems, where the AC and DC sides are independent, making IGBTs ideal for managing renewable energy sources and offshore wind farms.

4. Gate Turn-Off Thyristors (GTOs)

- **Function**: GTOs are high-power semiconductor switches used in some HVDC systems, particularly in converters.
- **Working**: Unlike traditional thyristors, GTOs can be turned off by applying a gate signal, allowing better control of power flow.
- **Application**: Used in high-power converters for controlled switching in HVDC applications.

5. Capacitors

- **Function**: Capacitors store and release electrical energy, helping to smooth voltage fluctuations and improve voltage stability in HVDC systems.
- **Application**: Used in both **AC filters** (to mitigate harmonics) and in **DC smoothing** circuits to reduce ripple in the DC output of converters.
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6. Inductors

- **Function**: Inductors store energy in magnetic fields and help smooth current variations.
- **Application**: Used in DC circuits and filters to reduce current ripple and harmonics, ensuring a steady DC current in HVDC lines.

7. Filters (AC and DC)

- **Function**: Filters eliminate **harmonics** and smooth out voltage and current fluctuations caused by power electronics switching.
- **Application**:
  - **AC Filters**: Reduce harmonic distortion on the AC side of the converter.
  - **DC Filters**: Reduce ripple and noise on the DC side of the converter, ensuring clean transmission.

8. DC Circuit Breakers

- **Function**: DC circuit breakers interrupt the DC current flow in the event of a fault, protecting HVDC equipment and the transmission network.
- **Application**: Used to isolate parts of the HVDC system during faults or maintenance. They are especially crucial in modern VSC-based HVDC systems for fault isolation.

9. Power Electronic Controllers

- **Function**: Advanced control systems that regulate and monitor the performance of HVDC converters and other power electronic devices.
- **Application**: Controllers use fast digital processors to ensure smooth operation, precise control of voltage, power flow, and system stability.

10. Snubber Circuits

- **Function**: Snubbers protect power electronics components like thyristors and IGBTs from voltage spikes and transients during switching.
- **Application**: Used in HVDC converters to increase the reliability and lifespan of semiconductor devices by absorbing excess energy.

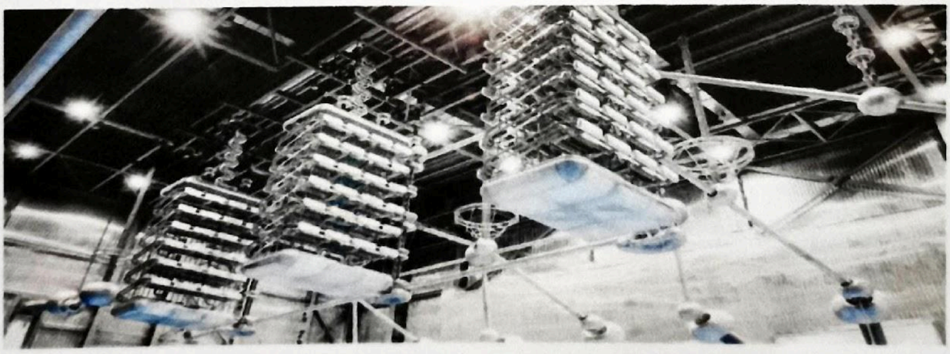

Figure: -Converter Transformer

PADGHE HVDC TERMINAL
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MSEB
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